

Transport Infrastructure LCA

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Main Research Question



Infrastructure is the skeletal structure of civil society.

What is the relationship between infrastructure provision and the society we create? Where are the levers for improvement?



Transport is a large driver of GHG emissions

World Greenhouse Gas Emissions in 2016

Total: 49.4 GtCO₂e



Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org



https://www.wri.org/resources/data-visualizations/world-greenhouse-gasemissions-2016



Life Cycle Assessment

"A process to evaluate the environmental burdens associated with product, processes or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and materials used and released to the environment; and to identify and evaluate opportunities to affect environmental improvements. The assessment include the entire lifecycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation and distribution; use, reuse, maintenance; recycling and final disposal"



Infrastructure comes first





What to build?

How to build?

Mansell P, Broyd T, Nicholson I, et al. (2020) Assessing the impact of infrastructure projects on global sustainable development goals. *Proceedings of the Institution of Civil Engineers - Engineering Sustainability* 173: 196–212



Construction LCA





LCA and transportation infrastructure...



Construction impacts



Energy use

9



Construction



Noland RB and Hanson CS (2015) Life-cycle greenhouse gas emissions associated with a highway reconstruction: A New Jersey case study. *Journal of Cleaner Production* 107. Elsevier Ltd: 731–740. DOI: 10.1016/j.jclepro.2015.05.064.



Division of responsibilities/Data



Saxe S, Guven G, Pereira L, et al. (2020) Taxonomy of uncertainty in environmental life cycle assessment of infrastructure projects. *Environmental Research Letters*. DOI: 10.1088/1748-9326/ab85f8

www.projectcartoon.com 2006



Energy needs for mobility









GEN	ERATION -	FUEL TYPE		
***	nuclear	44.1%	6,978 MW	>
%	hydro	27.9%	4,413 MW	>
- APP	wind	22.8%	3,604 MW	>
٨	gas	3.4%	531 MW	>
۲	solar	1.7%	272 MW	>
٠	biofuel	0.2%	39 MW	>
(4	import export net	164 MW 1,491 MW 1,327 MW	>

CO2e INTENSITY

17 g/kWh

LOW AVG HIGH



Maintenance/Refurbishment



Makarchuk, B. and Saxe, S. (2019) 'Embodied greenhouse gas emissions of the Spadina streetcar - A temporal approach including maintenance', *Journal of Infrastructure Systems*, https://ascelibrary.org/doi/full/10.1061/%28ASCE%29IS.1943-555X.0000475



Mode choice



Buehler, R. (2011) 'Determinants of transport mode choice: a comparison of Germany and the USA', *Journal of Transport Geography*. Elsevier Ltd, 19(4), pp. 644–657. doi: 10.1016/j.jtrangeo.2010.07.005.

Buehler, R. *et al.* (2017) 'Reducing car dependence in the heart of Europe: lessons from Germany, Austria, and Switzerland', *Transport Reviews*. Taylor & Francis, 37(1), pp. 4–28. doi: 10.1080/01441647.2016.1177799.



Demand response

"any policy that reduces congestion without otherwise making driving more expensive ... will tend to attract new traffic that at least partially offsets the policy's effect on congestion"

-Hymel et al 2010



Hymel, K. M., Small, K. a. and Dender, K. Van (2010) 'Induced demand and rebound effects in road transport', *Transportation Research Part B: Methodological*. Elsevier Ltd, 44(10), pp. 1220–1241. doi: 10.1016/j.trb.2010.02.007.

http://www.vtpi.org/gentraf.pdf



Induced Demand



Credit: Ryan Martinson



Transport - Land Use





City size with dominant travel mode

Feedback loop between transport and land use

Bertolini, L. (2012) 'Integrating mobility and urban development agendas: A manifesto', *disP*, 48(1), pp. 16–26. doi: 10.1080/02513625.2012.702956.

Marchetti, C. (1994) 'Athropological Invariants in Travel Behaviour', Technological Forecasting and Social Change, 47, pp. 75–88.



Land use, land use change, and forestry (LULUCF)



City of Toronto, 2013



Transport Infrastructure and Land use: Long term impacts

Article

The impact of urban proximity, transport accessibility and policy on urban growth: A longitudinal analysis over five decades B Litban Analytics and City Science

Environment and Planning B: Urban Analytics and City Science (0) 1-18 (1) The Austor(s) 2017 Reprints and permissions.ray polit 10.1177/2399808317740355 journals.sagepub.com/home/epb

Roman Roads to Prosperity: Persistence and Non-Persistence of Public Goods Provision*

> CARL-JOHAN DALGAARD NICOLAI KAARSEN OLA OLSSON PABLO SELAYA

> > July 9, 2018

Dena Kasraian Delft University of Technology, The Netherlands; University of Toronto, Canada

Kees Maat and Bert van Wee Delft University of Technology. The Netherlands





End of life?

London Underground, 1863

Pons Fabricius, Rome, 62 BCE



https://www.bbc.co.uk/newsround/20953143

https://www.shutterstock.com/video/clip-11850530-bridgepons-fabricius-over-tiber-river-rome



Persistent and hysteretic



Burchfield, M., Overman, H. G., Puga, D., &Turner, M. A. (2006). Causes of sprawl: Aportrait from Space. TheQuarterly Journal ofEconomics, 121(2), 587–633. https://doi.org/10.1162/qjec.2006.121.2.587

Source Google Images



Network Effects



Lin, Bo, Timothy C. Y. Chan, and Shoshanna Saxe. 2021. "The Impact of COVID-19 Cycling Infrastructure on Low-Stress Cycling Accessibility: A Case Study in the City of Toronto." Findings, February. https://doi.org/10.32866/001c.19069.

Cycling Network Toronto



Holistic considerations...



Saxe S and Kasraian D (2020) Rethinking environmental LCA life stages for transport to facilitate holistic assessment. *Journal of Industrial Ecology*: 1–16. DOI: 10.1111/jiec.13010



So what?

• Transport infrastructure's boundaries are wide and long

• Infrastructure comes first

• Huge knock on (indirect) impacts

• Infrastructure choice nearly impossible to undo (need to stop digging)



Thank you!



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